STEAM TOWING
ON
RIVERS AND CANALS
BY
F. J. MEYER
AND
W. WERNIGH

V I

STEAM TOWING

ON

RIVERS AND CANALS,

BY MEANS OF A SUBMERGED CABLE.

WITH A

DESCRIPTION OF THEIR CABLE SYSTEM,

BY THE PATENTEES

F. J. MEYER

AND

W. WERNIGH.

LONDON: E. AND F. N. SPON, 48, CHARING CROSS.
NEW YORK: 446, BROOME STREET
1876.

GENERAL REMARKS.

:o:

For many years past the serious attention of the authorities and of the leading engineers on the Continent has been turned to the various means of utilizing and improving the extensive water communications of their respective countries, for the purpose of regular and cheap goods traffic.

Prior to the introduction of the railway system, rivers and canals were the sole recognised and possible means of transporting large quantities of goods at anything like reasonable prices. Since their introduction however, and owing to their development, the growth of trade has been so rapid, that many of the railways are now inadequate to the traffic they have so much assisted in fostering, while in many cases the goods to be forwarded are of such a nature that they will not bear expensive carriage. Frequently also, the lines themselves might be more profitably employed in forwarding goods and passengers at rates that would give them better returns.

It is for the carriage of large quantities of bulky, or cheap goods, at slow speeds and at low rates that, in France and Germany especially, so much attention is being devoted to the improvement of their rivers, and the development of their system of canals.

The advantages of water carriage as compared with that upon roads and railways, especially upon the latter, for such goods which, relatively to their value are of great volume, and the forwarding of which is not a question of hours, will be best appreciated, when it is remembered that a horse of average

strength will draw on a level road 1·5, upon a railway 15, and upon a canal or in still water 60 tons weight at equal speeds.

In France the Budget for 1877 includes 111,499,625 francs for improvements of rivers, 23,372,000 francs for canals, and 97,123,000 francs for harbours, a total of £9,279,785. The first two items are for improving the Eastern Canal, and for deepening the Seine, Rhone and the Burgundy Canal. Besides these sums on the part of the State, the City of Paris has voted £8,000,000, and the four departments Meurthe et Moselle, Vosges, Meuse and Ardennes together £2,560,000 exclusively for the Eastern Canal.

In Prussia upwards of 1045 miles of new canals are authorized and partly being built, in addition to the 1289 miles the country already possesses and to the 4925 miles of navigable rivers in Germany.

As a general rule the new canals are designed to unite rivers to bring large manufacturing and industrial places in direct communication with mining centres, or rich agricultural districts in connection with an existing waterway more or less distant.

And it is precisely this desire to develope and make the best use of the inland waterways that has created the necessity also for a new and reliable means of working the traffic, which while being economical should at the same time be equally applicable to lakes, rivers and canals, and yet answer all requirements as to space, draught, currents, curves, ice, rocks, locks, crowded or limited traffic, cheap rates and regularity.

With submerged Chain or Wire Cable towage it is alone possible to meet all these requirements, and practical success has been the gradual growth of many years' experience and trials; and much money and still more thought and labour on the part of foreign engineers have been expended in arriving at a satisfactory solution of the difficulties—peculiarly inherent to the system—to be successfully overcome, before it was possible to profit fully by the immense advantages secured thereby.

The system of Cable or Chain towing may be shortly explained thus:—A Wire Cable or Chain of the necessary strength is laid along the bed of the river, canal, or lake, and moored at its extremities. The tow-boat is provided with steam engines and suitable machinery for taking up the Wire Cable or Chain at the bows, and hauling thereon, whereby it propels itself and its train of barges at a speed varying with the requirements of the case, and re-lays the Cable or Chain by the stern as it progresses.

By this means the full force of the steam power is exerted without slip or waste of any kind, and the boat is able to tow a practically unlimited number of barges.

The advantages of this mode of propulsion, as will be readily understood, are very great, provided that the steamers and necessary plant are properly adapted for the purpose.

Irrespective of all the other advantages it offers, there is one, which in its application to canals and narrow rivers is of incalculable value, and that is, in obviating all wash of the banks. This washing of the banks, which is so destructive to canals, and which has been the principal reason why steam has not been more generally applied to canals instead of horse power hitherto, is caused mainly by the wash waves formed by the paddles or screw in acting upon the water in a confined space (especially where the depth is inconsiderable), coupled with high speed. As the towing steamer's power is exerted, not upon the water directly, but upon a fixed point, or a series of fixed points, represented by the Cable, and the speed is always under control, all destruction of the banks from this cause is entirely avoided.

As far as is known, at present, the first experiments in towage were made in 1732 by M. Le Marechal De Saxe. The practical application of this system however, dating from 1820, was first made at Lyons, on the river Saône. In this case the tow-boat was a flat-bottomed vessel of 17 feet beam, and 75 feet long, on which a wooden platform was erected to receive a

windlass worked by six horses, giving motion to the hauling drums, and round which the towage rope was wound. In the trials made in June, 1822, between Givors and Lyons, one-and-a-half miles of hempen rope, 2¼ in. diameter, was employed. This rope was divided into two equal lengths, and placed in one of two small barges called "courriers," which was towed up-stream by men and horses; one end of one length of the rope was then anchored in the channel, and the other end was wound several times round the drums on the tow-boat, which then commenced to haul on it, and paid the slack over the stern into the empty "courrier" following it. Meantime the first "courrier" had been sent on, and had anchored its second portion of rope, and on reaching the upper end of the first piece of rope, the lower end of the second piece was ready to be taken over the drums of the tow-boat, while the second "courrier," with the first length of cable on board, was again towed further up the river to anchor its length of rope afresh.

These trials having succeeded to a certain extent, the horses gave place some years later to steam power.

As it was soon found that the adhesion of a chain reposing on the ground is from 70 to 80 per cent. of the weight of that portion in contact with the ground, it was proposed to build tow-boats, which should apply their motive power to submerged chains, and the first practical trial in this respect was made at Rouen, in 1825, by De Rigny, who constructed a chain tow-boat there and laid down a chain along the river. After many trials and improvements with steamers, too numerous to mention here, a definite system of chain towage was eventually arrived at, such as is actually in use on the Seine, between Paris, Montereau, and the Oise; on the Elbe, between Hamburg and Schandau and on part of the River St. Lawrence, in Canada.

Experiments of a more perfect kind were continued for some years in Belgium with Iron and Steel Wire Cables; and in 1865 Baron De Mesnil, made experiments in Belgium and

in America, adopting the Fowler clip-drum, with a view to obtain a perfect grip on the Wire Cable.

In May, 1868, the Société Anonyme de Touage de Liége, was incorporated for carrying out cable towage on the River Meuse, and in December, 1868, the Belgo-Netherlands Towing Company, for working the Terneuze Canal from Ghent to the River Schelde.

The first section of the Liége Company's line was opened between Liége and Namur in the year 1869, and in 1870 extended to Maestricht, and thence along the canal (connecting Antwerp and Rotterdam), as far as Bocholt, a total length of 137 kilometres. Although the materials and plant were found on the whole to answer their expectations, and the results were satisfactory, yet on the Liége and Namur section the service was gradually given up temporarily, on account of the large number of oldfashioned locks and weirs which occasioned such loss of time in passing the trains of barges that it was found more profitable to work this section by horses. There are ten sets of locks on this short length of canal, each of which took a train of barges, with its towing steamer, two hours to pass through.

The Belgian Government, however, has finally been brought to see and understand the importance of cheap water carriage, as carried out on a regular system, and it has learnt to understand, that to neglect inland water traffic for the sake of feeding its railway system, is contrary to all true principles of economy. It has, amongst other works, undertaken the re-building of these locks of sufficiently large dimensions to pass several barges at a time, and far more speedily than through the old ones.

The Cable employed on the Meuse is 1 inch diameter, and formed of 42 wires wound in a spiral round a tarred hempen core. Its weight is 1·5 lb. per foot, its ultimate breaking strain 290 cwt., and its safe working strain 41 cwt. A Chain to withstand the equal strains would require to be made of ·78″ iron weighing 6·1 lbs. per foot, or nearly four times as heavy.

The tow-boats employed were of two different kinds, but the principle aimed at in both cases was to make use of Fowler's clip-drum for getting the necessary grip on the Cable. In both cases the Cable is taken along the side of the Steamer; in one, Fowler's drum is placed vertically, projecting with other wheels and gearing, beyond the Steamer's side, and in the other design it is placed horizontally under the deck.*

In France, towage on the chain system is at work from Montereau, through Paris as far as the mouth of the Oise near to Pontoise, and also on the river Oise.

The Chain first employed was made of ¾ in. iron, and weighed from 5 to 5½ lbs. per foot, and was tested to an an ultimate strain of 180 cwts. before being laid down, as it was supposed that the working strain would never exceed 60 cwts.; but after a short trial it was found inadequate to the purpose and was replaced by a new chain of ·88″ iron weighing 7.37 lbs. per foot and tested to 240 cwts. It is doubtful whether this Chain will last any length of time, as it is admitted that frequently sudden strains are developed, (partly owing to the weight and construction of the Chain and to the entire system of Chain towage) which reach as much as 180 cwts., while the constant working strains vary between 80 and 90 cwts.

The first Steamers adopted were of 16 and 25 H.P., but as they were found insufficiently strong for the purpose, others were soon built of 40 H.P., intended to go at four miles per hour upstream and eight miles downstream; these speeds however are never attained, when there is any train of barges in tow.

On the lower Seine, a Steamer called the Napolèon, was built by M. Cail, at the cost of £9000, fitted with engines of 50 H.P., but it is found, that a smaller class of Steamer is better suited for that river.

* Both arrangements with Fowler's clip-drum are objectionable, as we shall show further on, the sole redeeming feature being the possibility of *getting rid* of the Cable at any moment, but which then leaves a Towing Steamer as useless as a locomotive off the rails.

In the United States, a length of upwards of 42 miles is now in successful operation on the Erie Canal, between Middleport and Buffalo, and in this case it has been practically proved that the present speed by animal power can thereby at least be doubled at the same working expense. The heaviest load towed by a cable Steamer on the Erie Canal comprised seven barges carrying 1500 tons of coal against a current of three miles an hour at a speed of three miles. The State offered a prize of $100,000 for a successful introduction of steam on the Erie Canal, and paid $50,000 to the most meritorious for the purpose intended. The only success is the Wire Cable towing system, whereas every attempt to introduce steam as a motor on each canal boat has proved a failure, being unable to compete with animal power, and except at cost equal to that of a new canal boat, in being practically applied to the existing 5000 canal boats, which would represent an investment of ten millions of dollars.

In Russia, the traffic on the river Shecksna is being worked by a cable; last year the dividends paid exceeded 18 per cent. per annum.

The upper Volga, between Twer and Rybinsk, is being worked on the Chain system, a distance of about 210 miles by means of ten Towing Steamers, and although in the first year of its existence it had many difficulties of an exceptional nature to encounter, it is now beginning to produce very fair returns.

The Imperial Government granted a concession for laying a cable down along the whole Marinskie canal and river system, between Rybinsk and Petersburg and Cronstadt, a distance of 600 miles, and also on the Russian part of the river Vistula, from the Austrian frontier through Warsaw to the Sea Coast.

In Germany, the river Elbe is worked by the Chain system, laid from Hamburg to Schandau, a distance of about 425 miles, and it answers well, having paid dividends for some years at the rate of 6½ per cent. per annum, besides having a large reserve fund.

A Company on the Rhine has received a concession for laying down towage on the German portion of the river, and a section is already at work; but the system of Steamers they have adopted, to which we shall refer further on, presents so many drawbacks, that they must either abandon their system or their line. The lower Rhine from Rotterdam to Elten, belonging to Holland, has been conceded by the Dutch Government, and will be carried out on the Wire Cable system.

On the river Oder the Wire Cable system has been laid and tried and found to succeed, and our system of Steamers adopted, and will be shortly carried out.

The daily increasing importance of this system of improved inland navigation is shown by the concessions granted by the Prussian Government to Mr. F. J. Meyer, for towing by Chain or Cable on the rivers Havel and Spree in North Germany, thereby bringing the cities of Berlin, Hamburg, Stettin, Dresden, and the Saxon and Bohemia coalfields, and by means of the Oder, the Silesian coalfields, ironworks, and mines, and Polish and West Russian timber and agricultural districts, into communication by this cheap and efficient means of transport.

The distance embraced in the concessions is about 230 miles, and comprises the river Havel from its junction with the Elbe at Havelort to Hennigsdorf (whence there is communication with the lower Oder, *via* the upper Havel and the Finow canal); the river Spree from Spandau through Berlin to Cöpnick, with a branch line up to Rüdersdorf; another line along the Spree to Newhaus (the western end of the Friedrich Wilhelms Canal, communicating with the upper Oder), and a third branch by the river Dahme to the Neuen Mühle Lock; and lastly along the new Sacrow-Paretz Canal, and the Schifffahrts Canal, from Berlin to Tegelort on the Havel.

The whole of these waters have been carefully surveyed and sounded, and it has been found, that although the depth varies considerably in different parts of the course, as for example in the Muggel See, where the depth attains 27 feet, and in the

'ide Havel 45 feet, while in some portions of the upper Spree, the direction of Neuhaus, there is but an average depth of three et of water, yet upon the whole, neither depth nor shallowness esent any great obstacles in laying and working the line, the ly additional outlay being for dredging works in deepening the allow parts of the channel. One advantage, in point of econny in working, these waters have over other rivers now being rked by this system of towing, lies in the fact that the current for the most part sluggish, not exceeding two to three miles per ur, except during spring time. On certain parts of the Elbe, on e contrary, it runs at a speed of five miles an hour, and on the ecksna, in Russia, (a tributary of the great Volga) there is one ot where the trains encounter successfully a current of eight ten miles per hour in flood time.

In the case of these concessions, which are undoubtedly the y to an immense system of towage, which will shortly spread roughout and embrace all the waterways of Central Europe, ere are several points worthy of remark.

Whereas traffic on other lines has had to a certain extent be created and nursed, here it is already immense, and accordg to all returns is growing larger every year.

The City of Berlin, the centre of the German Empire, ntains a million of inhabitants, and is built in the middle of a ndy plain utterly unproductive of anything except small tatoes. The inhabitants require not only to be fed, clothed d lodged, but all the raw materials for the supply of their mberless factories and industrial works have also to be brought om long distances. The increase of population averages 50,000 year, and this is equivalent to an augmentation of about 500 uses built annually; and all the materials, such as bricks, ones, timber, limestone and so forth have to be brought from a stance by water to Berlin. Hence results the enormous traffic these rivers, in all articles of food, hay, fruits, market proce from intermediate towns and villages, brown coal or lignite, d coal *via* the Upper Elbe from Bohemia; iron, petroleum and

general merchandize by the Lower Elbe from Hamburg; and coal, iron and other metals, timber and foreign merchandize by the Oder from Stettin and Breslau.

The amount of traffic on the Berlin waters embraced in these concessions, as shown by the Police Returns, is very considerable. In 1874 the Returns of Goods entered, despatched or passed through Berlin only by water, amounted to 70,346,872 cwts. exclusive of floats of timber.

There is besides a large intermediate traffic which it is next to impossible to determine accurately. It is of an important and extensive character, as apart from the ordinary local traffic the numerous brickworks and manufactories have to be supplied with raw material and fuel, the latter of which reaches its destination principally by the Havel and Spree rivers, *via* the Elbe, from Bohemia. This intermediate traffic certainly exceeds 500,000 tons—probably it is really more than double this if the number of villages and small towns bordering on these rivers and lakes are taken into consideration.

The working of the Government Limestone Quarries at Rüdersdorf, east of Berlin, results in an annual output of upwards of half a million of cubic meters of different kinds of limestone, being equivalent to about 1,250,000 tons, and more than three-quarters of this finds its way to Berlin by water, the duration of the journey averaging three days.

Upwards of 15,000 tons of coal from Bohemia are consumed annually at these Quarries, the whole of which would be carried along these waters and delivered at 40 % less cost than at present, as soon as punctuality and honesty could be secured.

The lines of railway to Berlin are already overworked; it will therefore be a relief to them to be rid of a large portion of their cheap and heavy traffic.

The barges get no assistance to their progress from the stream, which is mostly against them. In many parts there is insufficient room to sail; and even in those portions of the water which are wide enough, the way is tortuous, and every quarter of

an hour brings a change in the direction of the channel. Horses cannot be used, as the river banks are not provided with towing paths. There is, therefore, but one mode of propulsion left—namely, poling, which is the sole reliable resource for all this immense traffic; and a more arduous, degrading, and inefficient toil cannot well be conceived.

At present it is impossible to say beforehand how long a barge will be on the road; it is not a question of days or weeks, but often of months. Now, one of the principal advantages of towage, and which cannot be too strongly insisted upon both in this as well as in every other case, is that of punctuality; and whereas a barge now takes a fortnight as a moderately quick journey from Havelort to Berlin, though frequently longer, when the entire line is completed, it will be possible to deliver it at Berlin the third day. This must necessarily have a direct influence upon the cost of carriage.

The cost of barge hire for 100 tons of cargo to go a distance of 150 miles, taking only ten days on the road, including the crew and all expenses, averages about £11.

The hire of a similar barge, forwarded by towage, and delivered that distance, the third day will cost about £4 10s.

With this example in view it would appear at first sight that the barge owners will be the losers; but this is, however, not the case; because, although barge hire is considerably reduced, wear and tear, working expenses, men's wages, and the time necessary to make the journey are reduced more than in proportion to this difference in price.

Moreover, a barge is burdened with heavy mast and rigging, weighing from 7½ to 10 tons, so much dead weight, which done away with, would considerably increase its carrying capacity.

There is another fruitful cause of loss to merchants and others forwarding goods in bulk by water at present, and that is frequent theft. The longer a barge is on the road, the greater the loss in this respect. I know a case in which a barge con-

taining 92 tons of lignite, from Bohemia, arrived at Berlin with 78 tons 14 cwt. only. This state of things is more generally the rule than the exception, and it is only by adopting a regular and speedy means of transport, in which everything is under control, that this can be remedied.

That the importance of these lines of towage may be more readily understood and appreciated, we add a few words here in reference to towage on the Oder, and the way it is proposed to carry it out, which, as it will form one of the principal feeders of the Berlin system, is of some interest.

The river Oder takes its rise in the high lands of Upper Silesia and flows past Ratibor, Cosel, Breslau, Frankfort and Stettin into the Baltic at Swinemünde. It is navigable from Ratibor, a total length down to the sea of about 530 miles.

The total fall in this distance equals about 508 feet. The current in the upper portion of the river is in some parts rapid, attaining a velocity at ordinary levels of 3·5 to 4·5 feet per second, especially between Cüstrin and Frankfort.

The volume of water varies very considerably. In spring time it rises to an average of 14 feet above 0 Swinemünde water level, and in the driest summer falls to 1·6 and 2·0 feet below 0.

For various reasons it has been neglected until within the last few years; but now the necessary works are being carried on actively to regulate it, and in the course of a few years it is to be hoped it will be second *to no river in Europe in commercial importance.*

At Cosel it is connected with the Silesian Coal fields by the Klodnitz Canal, a length of 40 miles. In its course down to the sea it receives many tributaries, and above Cüstrin it joins with the Vistula, *via* the rivers Warthe and Netze and with the upper Prussian Canals, &c. Westwards it is united by means of the Finow Canal at Hohensaathen and the Frederich Wilhelm's Canal at Neuhaus with the Berlin water system by the Havel and Spree and thence with the Elbe and Hamburg. It commands the transports of the produce of the Silesian mines, and in its course it flows through a rich and prosperous agricultural country.

The Coal fields of Silesia cover an area of upwards of 3000 square miles. The output in 1875 of the 146 coal mines amounted to 10,444,361 tons, having during the last four years increased by 3,887,159 tons There are also many important iron, zinc, and lead works (166) the output of which last year amounted to 18,704,965 cwts., and extensive limestone quarries, firebrick, brick, tile, hardware, porcelain and glass works, chemical works, machine shops, spirit distilleries, oil mills and beet sugar factories, (47) — cotton, linen, woollen cloth and paper mills. Previous to the development of the railways the various industrial resources of Silesia remained but little noticed; but since their development, the growth has been sure and rapid.

At present Breslau is approached by six different lines of Railway, three of which with numerous branches traverse the Coal fields. These lines which carried, in 1874, 13,369,453 tons, and of which considerably *more than the half* travels in the direction of Stettin, Frankfort and Berlin, are totally inadequate to the increasing demand for carriage. It is a fact worthy of note, that the leading lines have been paying exorbitant dividends (in 1874 the earnings amounted to £5,211,839), produced mostly by their goods traffic, and therefore every person interested in the industry of the country looks forward anxiously to the time when their produce can be forwarded by the cheaper and more commodious means of water transport than at present.

Gleiwitz, Cosel, Oppeln, Brieg, Ohlau, are small towns on the river above Breslau. They contain a number of factories and works of various descriptions.

Breslau, the capital of Silesia, is the second town in Prussia, with about 240,000 inhabitants; it is situated on either side of the Oder, and contains numerous large industrial establishments of all kinds, and is at the same time the centre of the whole trade of Eastern Germany and a greater part of Poland. The principal goods imported by way of Hamburg, Stettin and Berlin to Breslau, comprise raw cotton, wool, silk, wines, magnetic iron ore, petroleum, machinery, principally agricultural. The exports being iron, coal, zinc, corn, spirits, paper, cloth and cotton goods, chicory, sugar, tobacco, &c.

Only two railways have given Reports for 1874 on the import and export trade of Breslau, which by these lines amounted to—

Breslau-Schweidnitz Railway	....	1,546,826 tons.
Rechte Oder-Ufer Railway	....	1,455,860 ,,
		3,002,686 tons.

These figures do not include the through traffic from Upper Silesia to Berlin, Stettin, &c.

Maltsch, Leubus, Steinau, Koeben, Glogau, Carolath, Neusalz, Rothenburg, Crossen, Fürstenberg are small towns lying on the Oder, and their importance merely consists in their being the centres of their respective districts for the sale and transport of the produce of the agriculture and industry of each district, and for the supply of fuel and manufactured goods required in the neighbourhood.

Frankfort is a large manufacturing town situated in the Oder valley. The imports and exports, in 1874, amounted to 1,142,625 tons. Its principal trade lies with the neighbouring small towns and with Breslau, Stettin and Berlin.

Cüstrin, Schwedt and Greiffenhagen are also small towns receiving the produce of the country and supplying fuel and goods required for the use of the inhabitants of those districts. Cüstrin is the centre of the Beetroot Sugar trade of the Oder valley, there being 47 large Beetroot Sugar factories in the neighbourhood.

Stettin is a large manufacturing and shipping port, containing about 83,000 inhabitants. It has several iron and machine works, and mills of various descriptions. It owns a line of steamers running to America, and does a considerable shipping trade with England and its Colonies, and with French, Italian, American, and Baltic ports. Greater part of the foreign trade of Breslau is carried on through Stettin. In 1873, 997,180 tons of grain, 37,400,000 litres of spirit, and 38,215 tons of rape oil were shipped from Stettin, the principal portion coming from the upper Oder. 421,400 barrels of petroleum and 735,597 tons of

other goods were imported, and 225,103 tons were exported by sea. By rail 300,591 tons of goods arrived at Stettin, principally from Breslau and Berlin, and 604,602 tons were sent off by rail, principally in the same direction. The number of barges arriving in Stettin was 8,466, carrying 538,134 tons, and those leaving amounted to 8,472, carrying 537,974 tons.

Swinemünde is a small town situated at the mouth of the Oder, where it flows into the Baltic. No extensive trade is carried on, but it is the residing place of a large number of Oder and Baltic pilots.

At present the greater part of the coal, iron, and manufactured goods produced in Silesia is carried by rail at very considerable cost, simply because no regular system of transport exists on the Oder for the cheaper carriage of the same. Of the 10,400,000 tons of Coal worked in Silesia at least two-thirds finds its way by rail to Breslau, Berlin, Dresden, Frankfort, Stettin, and the neighbouring towns. Of this amount, Berlin alone takes 822,714 tons, Stettin 45,750 tons, and Frankfort 126,540 tons.

Although statistics are wanting to prove where the whole of the Silesian Coal produced and sent off is consumed, and as it is not traceable beyond these towns and the Oder districts, the only conclusion to be arrived at is that the greater part of the remainder directly unaccounted for, is consumed in the numerous small towns and places bordering on the Oder. There is therefore a large quantity of goods, which absolutely require cheap carriage, to be dealt with. The lowest rates per rail for Coal from Silesia (Königshütte)

to Berlin	equal	13/4	per ton,
to Stettin	,,	15/9	,,
to Brandenburg	,,	15/8	,,

In all cases, although the coal is brought to the town, yet great expense is still incurred before it reaches the consumers. Amongst other items of expenditure is that occasioned by a general regulation—that waggons of coal arriving at Breslau, Berlin, Stettin, Frankfort, or any other station, have to be

unloaded within six hours of notice of arrival, or a fine of 6/- per day has to be paid. Most of the factories and coal depôts have water frontage; but there is no railway in Germany that has any wharfage, and therefore the cost of carriage from the Railway Station averages another 3/- a ton.

Very little Silesian Coal is exported now, but as soon as it can be brought to Stettin for 12/- a ton, it will be able to command a considerable share of the Baltic Coal Trade.

Of the manufactured goods, such as Iron, Steel, Cloth, Hardware, Lime, Cement, &c., the larger part finds its way to Berlin and Stettin, and of course is under still greater disadvantages than coal respecting high freights.

The freight for ordinary manufactured goods in quantities of not less than 10 tons between Berlin and Breslau is from 38s. 3d. to 23s. per ton. Between Stettin and Berlin from 10s. to 5s. 7d. per ton, and between Stettin and Breslau from 46s. to 27s. per ton.

Now as regards the traffic on the Oder, upstream from Stettin, it can be explained very briefly. The barges from Stettin *en route* for Berlin require to be tugged up to the mouth of the Finow Canal or the Friedrich Wilhelm's Canal, as the river not being tidal flows only in one direction, downstream. Therefore between these points there is already a considerable up traffic. Higher up, the currents and the smaller depth of water present greater obstacles to ordinary sail navigation, while the cost of tug steamers is too great to allow of their being generally used. (Nevertheless the First Stettin Tug Company paid dividends last year of 38 per cent., and the new Company dividends of 10 per cent.) Between the mouth of the river Warthe and the Finow and Friedrich Wilhelm's Canal, there is a very considerable traffic in timber, mostly coming from Poland. In 1871, the Oranienburg Lock (Finow Canal) passed 14,759 floats of timber, and the Neuhaus Lock (Friedrich Wilhelm's Canal) 2,190 floats (9 logs = 1 float); these quantities have since then largely increased.

The traffic between Swinemünde and Stettin comprises the passage of sailing vessels and steamers, the former of which have mostly to be towed to and from Stettin. Last year the number of sailing vessels from foreign and German ports entering and leaving Stettin was 2508 and 2395; the number of steamers being 1302 and 1259 respectively.

A proper service of towage, barge accommodation, and proper arrangements for easy and expeditious loading and unloading, would undoubtedly command to a very considerable extent, the amount of traffic now existing along the proposed line, especially as goods can be profitably forwarded at less than half the lowest railway rates.*

In order to carry out the Oder towage completely, in such a manner as to meet the demand of existing and future traffic, and by well combined and perfect arrangements to carry on this traffic regularly and cheaply, it will be necessary that the undertaking be carried out at once on a comprehensive scale. The conditions of trade and country are such that in working out this undertaking regard must be had not only to the existing traffic, but also to a much larger one to be made and diverted to the system. And that this is reasonable, will be easily seen on comparing the various rates, and on estimating the comparative costs of working railways and towage, and especially taking into consideration the various advantages offered by the latter.

The line of towage will commence from Swinemünde and crossing the Little and Great Haff run up to Stettin. This comprises a length of about 90 miles. From Stettin the line will continue up the Oder past Hohensaathen, the junction of the Finow Canal, and up to Cüstrin, the junction of the river Warthe. Thence to the Brieskow Lake, the junction of the Friedrich Wilhelm's Canal, and from there past Breslau up to Cosel, the junction of the Klodnitz Canal, leading to the coal fields, and embracing a total length of 497 miles. As the Klodnitz Canal contains 18 locks, while it has a very large reserve of water, it

* **Remark.** The whole of the above figures and quantities have been extracted from the various Board of Trade Reports, Government Statistics, Consular Reports and Railway Tariffs.

would not be necessary to lay down a cable for the present. The different classes of traffic to be dealt with require the construction of different sizes of towing steamers and barges. On the section between Swinemünde and Stettin, provision has to be made for the towage of sea going vessels, and for that purpose three towing steamers of 4 feet draft and indicating about 240 horse-power, are advisable. Between Stettin and Brieskow Lake, 12 ordinary light-draft towing steamers must be employed, but of the same power and description of engines and towing apparatus as in the first case. Between Brieskow and Cosel, 10 smaller light-draft steamers will be necessary, indicating about 160 horse-power.

In order to be to some extent independent of the ordinary barges on the Oder, it will be necessary that barges in sufficient number be secured to allow of the coal and direct traffic being taken in hand at once. For this purpose 370 barges will be requisite for the commencement; and these, which will have a total tonnage of 52,500 tons, will be sufficient to keep up an annual carrying trade of 1,000,000 tons.

It should be remarked here, that as soon as the line is in operation, barge accommodation can be rented to any extent required, while the whole of the general traffic of the river will be undoubtedly towed up-stream. For the easier loading, unloading and transhipment of coal, ores and merchandize, 2000 iron coal buckets, each to hold from 20 to 25 cwts. should be used. As a large profit also can be earned from the export of the coal to German and foreign Baltic ports, it would be advisable that Steam Colliers be acquired. The dredging works in the river necessitate the supply of six steam dredgers, with their sand hoppers, etc., and for Stettin and the Brieskow Lake, it would be necessary to advise the supply of four ordinary tug steamers, especially with a view to the timber traffic at these points.

Commodious and proper workshops and slips must be erected at Stettin, Frankfort, Breslau and Cosel, and these repair and workshops must be capable of carrying out any other small work which may be offered, besides that required for the repair

and construction of the plant. Coal depôts, goods stations and loading places must be acquired and established at Gleiwitz, Cosel, Breslau, Glogau, Frankfort, Cüstrin, Stettin, and Swinemünde; while at Oppeln, Brieg, Ohlau, Koeben, Brieskow, Cüstrin and Schwedt arrangements should be come to with the proper persons for smaller depôts to be held in each place. The establishment of these coal depôts is most desirable, as they will not only supply a want long felt in those places, but will, at the same time, prove to be a source of direct profit from the sale or storage of the coal and the storage and wharfage of goods. Travelling steam cranes for the transhipment and unloading of the coal should be furnished and erected at Cosel, Breslau and Brieskow.

It being a matter of primary importance that the Cable should be, from the first, well laid and maintained, it is requisite to include the construction and supply of two steamers to be specially devoted to this purpose.

The forwarding of the existing goods traffic on these lines conjointly, by means of Wire Cable Towage, will produce a net profit of over £280,000 annually, the rates and charges being as shown in the accompanying table :—

RATE OF CHARGES FOR TOWING A BARGE (SAY 100 TONS CAPACITY) AND CARGO:

Distance.	CHARGE FOR UP STREAM, *Down Stream 20 % less.*			
Mile.	Empty Barge per Mile.	Laden Barge per Mile.	1 Ton of Cargo per Mile.	Tow Ropes per Mile.
1	d. 5·6	d. 2·9	d. ·15	d. ·58

In order that a just appreciation of the difference in price may be arrived at between towage and carriage per rail, the following table gives the minimum and maximum rates for the forwarding of goods by land and water, so far as these great German towing lines are concerned, and I have no reason to doubt, that this comparison will also hold good in other countries, especially in England and France.

COMPARISON OF RATES BY RAIL AND BY WATER FOR 100 TONS.

	From Berlin to Stettin.		From Gleiwitz to Berlin.		From Gleiwitz to Stettin.		From Berlin to Hamburg.		From Berlin to Magdeburg.	
	DISTANCE.		DISTANCE.		DISTANCE.		DISTANCE.		DISTANCE.	
By Rail	84 Miles.		299 Miles.		322 Miles.		178 Miles.		89 Miles.	
By Water	121 „		337 „		447 „		248 „		107 „	
	CHARGES.		CHARGES.		CHARGES.		CHARGES.		CHARGES.	
		£ s. d.		£ s. d.		£ s. d.		£ s. d.		£ s. d.
By Rail — Lowest .... (Say for Coals.)		17 5 0		66 13 4		78 15 0		36 12 0		18 6 0
By Rail — Highest .... (Say for heavy Merchandize)		44 16 0		159 12 0		171 17 0		94 18 0		47 9 0
	£ s. d.		£ s. d.		£ s. d.		£ s. d.		£ s. d.	
By Water — Cargo of 100 tons	7 11 3		21 1 3		27 18 9		15 12 0		6 13 9	
By Water — Barge of 125 tons capacity	1 11 0		4 7 0		5 15 0		3 4 0		1 7 0	
Barge Rent	1 1 0		2 16 0		3 17 0		2 2 0		1 1 0	
		10 3 3		28 4 3		37 10 9		20 18 0		9 1 9

It is to be hoped that the day is not far distant when the full advantages of this system of cheap carriage will be recognized, even in England, and then some of our old canals and many new ones which might be profitably built to carry it out, will help to break through the present railway monopoly. It must ever be a recognized truth, that water carriage is cheaper than railway carriage, and when worked on this system, which may best be compared to a railway with a self-maintaining and level permanent way, there can be no doubt, that for the transport of heavy goods at low speed, it will prove the solution of a question of grand national importance, not only to the English manufacturer and merchant but to the whole English commonwealth.

WIRE CABLE.

When Towage was first introduced, its advocates generally adopted Chain as the material to be submerged for towing upon. This was of course natural, as it was requisite to have something that should be strong enough to withstand great and varying strains and sudden jerks, at the same time be pliant and easily moveable, and yet capable of withstanding for a great length of time submersion in rivers or lakes, exposed to the chemical action of decomposing matter on the river bed, or where rapids occurred, from injury by attrition with a coarse sand or pebbly bottom and sharp edges of stones and rocks. Ropes made of flax or hemp had been tried; but sufficient strength could not be obtained in anything like a useful size; and besides this, they very soon rotted from the constant exposure to air and water. Bars of round iron welded together, forming one continuous line, had also been essayed, but unsuccessfully, on account of the absence of elasticity and pliancy. So long, therefore, as chain was the only material that could be employed for the purpose, it received the sole attention of those interested in lines of towage, and hence in course of time it came to be looked upon as part of the system. But as soon as it was found possible to manufacture Wire Ropes or Cables a fresh impulse was given to towage, and the way opened of attaining results utterly beyond the limits to be secured by the employment of chain.

Experience has shown that the adhesion of a chain upon the ground is from 70 to 80 per cent. of the weight of that portion in contact with the ground, which of course, all advocates of chain towage have seized upon as a fact of great importance, forgetting at the same time, that the friction of the chain, wear and tear, and waste of power, are in exact proportion to its weight and its adhesion to the ground.

It soon came to be generally admitted that wire cable was the towing medium of the future; but it brought with it difficulties of a technical nature, the really satisfactory solution of which has puzzled and defied the many attempts hitherto made.

Strength for strength, the relative weight of chain and iron wire cable are as 42 to 11. The chain, say one of $\frac{5}{8}$ in. in diameter, is heavy enough to run off the steamer of its own weight with the slightest tension. A cable on the contrary, of $\frac{7}{8}$ in. diameter, requires, under certain circumstances, to be drawn on to, and nearly always to be re-laid from the steamer, by means of special apparatus, on account of its small weight. This fact hitherto has been little understood, and when it has been understood, imperfectly or incorrectly provided for.

When cable towage was first thought of, and indeed even now generally, it was supposed that any wire cable would suit for the purpose, provided its strength was sufficient. This is an error, however, and one of the principal ones that have been committed throughout.

Theoretically, a line of towage is the laying down of a cable in a straight line, and at unvarying depths, between two fixed points, upon which the haulage is performed by means of the steamer's engines, or other suitable appliances. Then only two essential conditions require consideration and fulfilment; the first the weight to be towed, reference being had to the current and depth, and, secondly, the speed at which the same is to be performed.

Practically however, in applying or laying down a cable there are numerous points which have to be taken into consideration, such as the general conditions of the river or stream, the sets of the current, the curves, the depths, the description of river bottom, varying depths of water either due to constant tide or to freshets and mountain floods, and all these points must be considered in conjunction with the probable amount, direction, and periods of greatest and least traffic. And even in straight lines, there are two difficulties to be avoided—that is, laying down the cable too sparingly, so that the constant tensional strains fore and aft of the steamer produce undue friction and usure; while, on the other hand, a too liberal allowance of cable will cause it to pack in the river whenever a steamer slackens speed

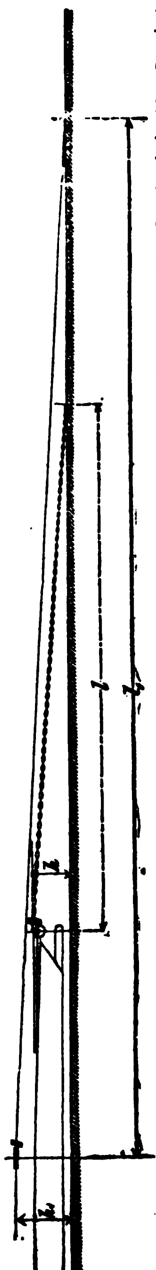
or stops suddenly. This packing of the cable, which consists in its coiling in heaps on the bed of the river, will occur in front or astern of the towing steamer according to circumstances. It is almost needless to add that this packing of the cable is one cause of kinks.

Indeed the various conditions under which cable can be employed for towing purposes necessitate so wide a divergence in the general plan of arrangements, that we have found it better to class its adaptation into two separate and distinct systems: the first as applied to large rivers and lakes, and the second as applied to canals and canalized rivers.

The general conditions of the river or stream comprise the maximum and minimum strength of current or tide along its whole course, or in any particular portion of its course. In most rivers it will generally be found that there are some especial obstacles, such as sandbanks, steep shores or shallow foreshores stretching far out into the stream, even extraordinarily muddy, rocky or sandy bottoms, weirs, locks, or artificial structures, such as quays, bridges, which beyond the question of fall, govern the passage of the water at particular spots and at particular times. The width and depth of the bed of the stream also influence the currents, while straight or broad reaches of water exposed to the action of a high wind, are subject to very considerable differences in depth. In this latter respect I can cite two cases, the mouth of the river Neva and the mouth of the Oder, where the differences in depth of water, caused solely by a high wind, attains as much as nine feet within a few hours.

The sets of the current, due in part to any of the above-named causes, or to curves in the channel, have also an important bearing on the correct position and length of the cable. It is found frequently that in curves the current is strongest on the outer side of the stream, while at other times pebbles, stones, or sand-banks having been deposited gradually on the outside of the curve, the channel is transferred more or less gradually to the inside. Varying depths of water, with the

attendant alteration in the speed of the current at those places, will materially alter the available length of the cable to be towed upon. Then, a line of cable that would be slack at a depth of 5 feet would be taut at 25 feet. And finally, the direction of the heaviest traffic which will necessarily be against the current, tends to cause the cable to creep down stream gradually. In laying it, therefore, all these points have to be previously carefully considered, and arrangements made to avoid or remedy the drawbacks they may occasion. In this respect experience has proved that in general an allowance of from three to five per cent. of the actual length of cable laid, over and above the channel distance to be worked, will amply suffice.



In canals and canalized rivers, where generally speaking, the depth of water does not vary more than two or three feet, and the channel itself is constant, and does not shift from side to side, as in the case of swiftly-flowing and wide-bedded rivers, the length of cable to be laid does not exceed at most two per cent. of the channel distance, except, of course, at the passage of locks, and here the increase depends mainly upon the means adopted for passing them.

The advocates of chain have urged against the cable as a drawback, the distance it is raised and put in movement in front of the ship, when being towed upon, which is in part due to its less weight, and in part to the comparative ease, as compared with chain, with which it is moved over the ground; in other words, its slight adhesion to the ground.

The annexed Figure (1) and following Table show the length the Cable and Chain rise in front of the towing steamer under different strains from different depths of water and at different heights above the steamer's line of immersion.

(Fig. 1.)

H = Vertical distance in feet from bed of river to point of application on steamer.

P = Total resistance to traction in lbs.

p = Weight of Chain or Cable in water in lbs. per foot.

L = Length of Cable raised = $\sqrt{2\,H.\frac{P}{p}}$

l = Length of Chain raised = $\sqrt{2\,H.\frac{P}{p}}$

	Ft.	In.	Ft.	Ft.
P = 50 Cwts.	H = 8	2	L = 292	l = 154
P = 40 „	H = 8	2	L = 262	l = 137
P = 30 „	H = 8	2	L = 226	l = 115
P = 20 „	H = 8	2	L = 190	l = 95
P = 15 „	H = 8	2	L = 160	l = 88
P = 10 „	H = 8	2	L = 131	l = 72
P = 5 „	H = 8	2	L = 65	l = 36
P = 1 „	H = 8	2	L = 42	l = 23
P = 50 Cwts.	H = 11	6	L = 344	l = 180
P = 40 „	H = 11	6	L = 312	l = 164
P = 30 „	H = 11	6	L = 269	l = 138
P = 20 „	H = 11	6	L = 223	l = 112
P = 15 „	H = 11	6	L = 190	l = 98
P = 10 „	H = 11	6	L = 154	l = 82
P = 5 „	H = 11	6	L = 78	l = 40
P = 1 „	H = 11	6	L = 52	l = 26
P = 50 Cwts.	H = 11	9	L = 351	
P = 40 „	H = 11	9	L = 314	
P = 30 „	H = 11	9	L = 272	
P = 20 „	H = 11	9	L = 226	
P = 15 „	H = 11	9	L = 193	
P = 10 „	H = 11	9	L = 158	
P = 5 „	H = 11	9	L = 82	
P = 1 „	H = 11	9	L = 52	
P = 50 Cwts.	H = 15		L = 397	
P = 40 „	H = 15		L = 354	
P = 30 „	H = 15		L = 308	
P = 20 „	H = 15		L = 249	
P = 15 „	H = 15		L = 216	
P = 10 „	H = 15		L = 177	
P = 5 „	H = 15		L = 88	
P = 1 „	H = 15		L = 56	

At first sight, these figures show a difference considerably in favour of the chain, whether in a straight line, or as applied to rounding curves of sharp radii. In shallow waters however, it has been found by experience that any inconvenience consequent thereon is a matter greatly due to the captain of the towing steamer. The inconvenience can momentarily affect only the traffic not being towed, or in rounding curves, the traffic coming from the opposite direction. The captain of a towing steamer can by a simple manœuvre give slack cable in front of his steamer, and thus so far remedy this as to avoid any hindrance to the ordinary traffic.

If considered as a question of friction and wear and tear, however, the advantage is all on the side of Wire Cable, for a chain which is under the most favourable circumstances four times as heavy, strength for strength, as the cable, on coming on the steamer has in consequence of its weight, to be led over a series of guide-rolls along the whole length of the steamer interrupted only while winding round the drums. These guide rolls form so many points at which the chain is jerked and worn away and the guide-rolls themselves annihilated by the continuous hammering of the links in their passage over them. Whereas a cable can come straight on to the taking-in apparatus, and after passing the drums is paid out again without any wear and tear; and in deep waters, as will be evident, this advantage is still more important.

In working a sharp curve with a long train of barges, requiring altogether a tractive power of say 5000 lbs., unless care be taken, the cable will naturally glide more or less over the river bottom, on the upper part of the curve, to an angle corresponding with the radius and extent of the curve. To avoid this, the steamer and train must enter and pass through slowly, and follow the outside of the curve as far as is feasible. The following sketch shows a couple of curves now being worked by us on the river Havel, without any assistance whatever beyond careful attention and management on the part of the captains, and this

with a general traffic in a narrow channel, sometimes exceeding 400 barges a day.

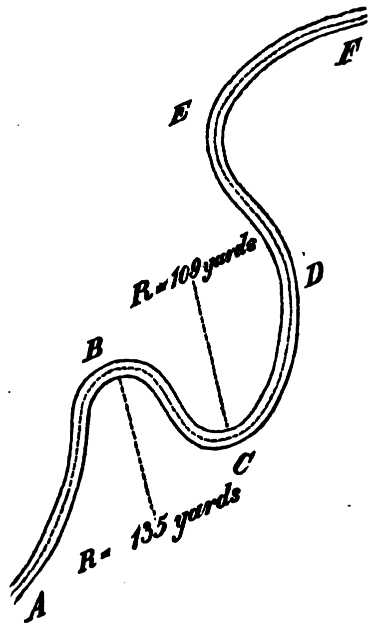


Fig. 2.
Distance from A to F 640 yards.

Should the curve be less than, say 100 yards radius, or form an elbow in the river, the channel narrow and the current swift, these difficulties can be successfully overcome by driving in a few piles at the head of the curve, as far forward as may be convenient without impeding the navigation, and by laying the cable on the near side as short as possible. The cable can now be towed on without risk of inconvenience. As the towing steamer proceeds up-stream, with stern well out and stem following nearer in the curve, the cable may, in the case of counter curves, be drawn against or round some of the leading piles, by which it will be confined within proper limits. The next steamer that passes down-stream will be careful to re-lay the cable as far out again as convenient.

In hilly or mountainous districts, where the current is frequently very rapid, and the river bends or doubles up as it

were, it is requisite to make other arrangements to overcome the difficulties of the passage. With a current of seven or eight miles an hour, a bend or two of 50 or 60 yards radius, and a narrow channel, were the cable or chain 20 times their ordinary weight they would be drawn out of place. The following sketch shows a couple of bends of the kind on the river Neckar.

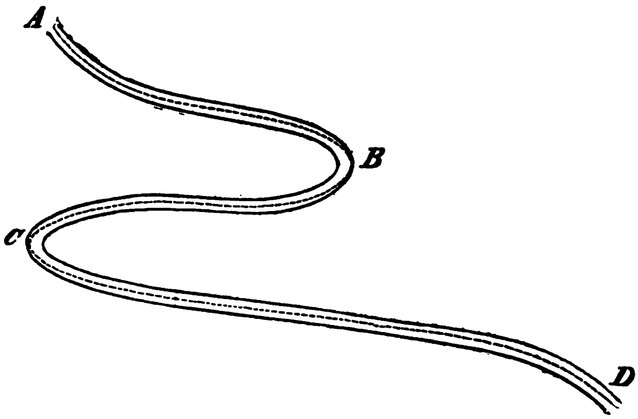


Fig. 3.

To remedy this we employ a small apparatus we term a slip hook at B and C, the object of which is to grip and hold fast the cable at those points.

The apparatus consists of a peculiarly-shaped and wide-faced hook, furnished with proper jaws to receive and hold the cable without damage to it. The whole is capable of being canted over, and so of releasing the cable at any moment by simply withdrawing a catch-pin, and as the hook cants over the jaws release their hold on the cable. The whole apparatus is fixed to an iron screw or strong timber pile, well secured, and when necessary, strutted. As a steamer approaches B up-stream, the cable is held in position by the hook; on arriving at B, and as the steamer swings round, the catch-pin is withdrawn on a signal from the captain, and the cable released. The steamer and train now make a fresh start in fair channel towards C. On arriving there the same operation is repeated. When the passage is clear, the cable which has been left lying in the channel, and a

few days' experience shows exactly where, is hauled on to a small boat, and thence by means of a light hand-winch to shore again, where it is replaced on the respective hooks. By this means the swiftest currents in the sharpest bends can be successfully and safely overcome.

In every curve the chain is subject also to be drawn over in a straight line, although not to so great an extent, on account of its much greater weight and adhesion to the bottom.

A difficulty that has existed hitherto in the use of Wire Cable for towing purposes has been its great liability to kink and knot together, or to get twisted into long spirals or corkscrews, which on being subjected to sudden strains, are drawn into a kink, or if they happen to form at a spot where there is too much cable, to get inextricably knotted together. Usually the kinks are found to occur below curves, when from the captain's negligence, the cable has not been properly relaid into the river; whereas the spirals are caused at places where a great strain has been brought upon the cable, perhaps occasioned by the sand or mud having embedded the cable, or by its having caught under a large boulder, or submerged pile or trunk, from which it can only be freed under great tension. The cable will then often come up quite vertically from the bed of the stream, and in so doing it is drawn over the edge of the steamer's fenders, causing displacement of the strands under tension, and if the cable is not of the requisite quality and springy enough to regain its original form on being relieved from this strain, the result is the formation of these spirals. One other cause of kinks, beyond a faulty design and construction of the towing steamers, lies in the quality and manufacture of the cable itself. Care requires to be taken in the manufacturing of the wire, as well as while the cable is being laid. When ready, there will always be found more twist in the cable than is represented by the number of turns the strands take in a given length, and before it can be employed for towing purposes the whole of this superfluous twist must be taken out of it. The harder and more

elastic the cable is, the more of this twist there will be in it, and the whole must be got rid of before it can be properly used for towing upon.

All these difficulties, however, can now be overcome successfully, and when they occur, completely remedied, provided that proper cable be employed, that it be laid in the river carefully and with a perfect knowledge of the character of the stream, that the design and construction of the steamers be such as to insure the cable being fairly used to its full strength—but not misused—and that the captains of the towing steamers exercise ordinary care and common sense in the fulfilment of their duties, for they, even more than an imperfect cable, are the cause of accident or injury to it.

Under equal strains a chain will elongate less than a cable; but on being relieved from the strain the elongation produced remains in it, and in this way the chain continues to elongate gradually when towed upon, until finally (if not previously worn out by continual friction) the links form into rigid bars, sometimes eight to ten feet in length, and is thus rendered quite useless. Besides this, the links of a chain being formed of one solid piece of iron, should a flaw occur, or should a weld be imperfect in any of them, the chain must snap. With a wire cable, on the contrary, if of the requisite quality, permanent elongation and rigidity are impossible; it will stretch considerably under tension, and when released will resume its former length, the hempen core allowing play for the stretching of the strands, so that its pliancy and elasticity are not injured by fair work. Should the strains brought to bear upon it at any time exceed its ultimate strength and a rupture be imminent, the strands will snap one after another, always giving sufficient time to prevent entire rupture. The risk of rupture of a wire cable is far less than that of a chain, from the fact of its being formed of a number of wires, each of which commences at a different spot, its homogeneity is much more perfect; but weldings in a chain, however much care may be bestowed upon its manufacture, will always continue to be a cause of weakness.

It occasionally happens that the cable or chain gets embedded in a sandy river subject to sudden floods, and if not used for some weeks. In such cases the cable can be freed far more easily than chain, which has often to be cut and abandoned if the depth exceeds three of four feet; for example, whereas on the Oder, the cable has been drawn out of a newly-formed sandbank from a depth of over seven feet.

Difficulty was anticipated in applying the towing system to canals, in regard to the passage of the locks; and here again the light and pliant cable possesses decided advantages over chain, as it can be conveniently passed over the lock gates or be suspended at a proper distance above on a couple of uprights, and let down when required for use.

In France and Belgium it has been found advisable to lay down the cable or chain through the lock. When the gates are closed it lies on the sills of the lock between the gates, where there is generally found sufficient room for it without risk of its being either jammed between the gates or of its preventing the gates from closing. M. Bouquié tried to pass the chain above the Aubervillers lock on the St. Denis Canal; but we understand that it was found to have several drawbacks on account of its weight.

As the result of many experiments we have found that a Wire cable of $\frac{7}{8}$ of an inch diameter is most convenient for all purposes of towing, both as regards size, weight and strength. The cable is composed of 42 wires of ·093 of an inch, nearly No. 13 B. W. G. Each wire has a cross section of ·0075 of a square inch and the 42 wires equal ·315 of a square inch. The centre of the cable is formed of a sound and compact hempen core, well tarred, not exceeding 5-16ths of an inch diameter. The lay of the strands composing the Wire Cable should be at 18 degrees, equalling one complete twist in $10\frac{1}{2}$ inches length. The weight of such a rope is say between 6·75 lbs and 6.875 lbs per fathom.

If made of good iron wire its ultimate strength will reach 253 cwts. (90,000 lbs. per square inch × ·315 of a square inch section). If of very strong charcoal iron wire, the ultimate strength will be 320 cwts. (114,000 lbs per square inch × ·315 of a square inch section).

If formed of American Chrome Steel which has been tested to 180.000 lb. per square inch, its ultimate strength will be 506 cwts. (180.000 lb. per square inch × ·315 of a square inch section).

Chain of equal strength, presuming the welding of the links to be infallible, will be from four to eight times as heavy.

If a chain breaks it can be easily repaired by means of a split link. If a kink or knot occurs in the cable which cannot be straightened without fracturing the wires it must be cut out and the ends spliced. This is an operation which requires an hour's work for two men, and when done carefully is as strong as the rest of the cable.

As it is convenient to have certain places in the cable where it can be separated, we employ a steel screw coupling which is found to answer the purpose very well. It is made of such a size as to pass over the drums and through the taking-in and paying-out gear without injury. The strength of such a coupling made of Chrome Steel equals a strain of about 180 cwts. It is found very useful for taking steamers off and for putting them on to the cable; and may be used for uniting a branch to a main cable, and in fact serves the same purpose as points on a line of railway.

At the extremities of each section of the line of Wire Cable it is advisable to place double swivels, so that any twist forming in the cable from any cause can easily be worked off.

Finally in regard to the durability of a Chain, it is calculated that one of good quality will last 10 years, and experience in this respect in regard to cable is not wanting to

prove that when worked under similar conditions, it will last considerably longer. Trials made with clip-drums, which, as is well known, destroy wire cable very speedily, proved that a good cable would last ten years.

At the works of Messrs. Felten and Guilleaume, in Cologne, a cable is employed for transmitting a force equal to twelve horse-power a distance of 1,193 yards, and has already lasted twelve years.

On the inclined plane of the Bergisch-Maerkische Railway at Hochdahl, 2,900 yards in length, a cable is used to draw up eleven trains a day, and lasts 4½ years.

On the Morris Canal, near to New York, cable was employed to draw vessels up the inclined plane; 60 barges per day for 250 days annually are hoisted by this means, and according to M. De Mesnil the cable would last nine years.

In coal mines the life of a wire cable is taxed according to the number of times it is bent. It is estimated in Westphalia that it will last out with perfect safety being bent 120,000 times. This, however, is but a rough way of guessing at best. It must depend entirely upon the quality of materials and workmanship as well as on the kind of bends, and the conditions under which such bends occur. At this rate, nevertheless, the cable employed for our system of steamers would last for 20,000 runs of a towing steamer, or 300 working days per annum, and two trips a day would bring the life of our cable to over 16 years. At present we estimate that a good iron wire cable will last ten years, and one of steel fifteen years.

There is little cause for apprehension in regard to oxydation of the wire cable, and the experience of the last five or six years can be brought forward in support of this.

As great as is in principle the difference between chain and ordinary towage, so is that between cable and chain towage, and in support of this we quote the opinion of the greatest authority on chain towage, Mr. Bellingrath, of Dresden, who says:—"I am convinced myself that it must be the work of the "future by means of properly constructed steamers to substitute "wire cable for chain."

TOWING STEAMERS.

The principle aimed at in towage consists in the forwarding of large quantities at comparatively low speed, and at little cost. Whether applied to ascending rivers, against a swift current, or to working Canals with next to none, the principle remains the same. Speaking generally, the advantages of employing force in the way it is applied in the different systems of towage, in direct haulage, consists in avoiding slip or waste of power on the water, and in avoiding the development of that resistant force in front of the vessel which is caused by the paddles or screw forcing the water away from the after body. This must not be confounded with the preceding wave which the prow of a ship drives along in front of her, and which of course occurs with the towing steamer as well as with any other vessel.

The loss of power due to slip only, in a well-built paddle steamer of ample draft in still water, is equivalent to about 33 per cent. of its total power. Therefore, if there is no current, the ship will be propelled forwards at the rate of about 67 per cent. of the speed of its paddles. But should there be a current = a in the stream, take the paddle-wheel speed = b, and the corresponding speed of the ship in still water = c, the useful effect of a paddle steamer will be represented by the following formula:—

$$100 \times \frac{c-a}{b};$$

experience has shown that

$$b = \frac{c}{67} = 1{\cdot}5\ c.$$

therefore the useful effect of the paddle steamer at present

$$= 67 \times \frac{c-a}{b}.$$

If, for example, a = 5 feet, and the ship is to progress at the rate of 3 feet, then c = 8 feet, and the useful effect will be—

$$= 67 \times \frac{3}{8} = 25{\cdot}12 \text{ per cent.}$$

If a = 12 feet, and the speed of the ship is to be 2 feet, then c = 14 feet, and the useful effect will be—

$$= 67 \times \frac{2}{14} = 9{\cdot}56 \text{ per cent.}$$

The slip of screw steamers in still water varies between 10 and 30 per cent. according to circumstances, but usually it may be taken at an average of 20 per cent.

But it has been proved in practice that the average total loss of power from resistance due to the stiffness of the cable and friction in going through the press-rolls and over the drums, is in our steamer from four to eight per cent., so that of the power developed in the engines, and brought to bear from them upon the cable and employed in direct haulage, from 92 to 96 per cent., works with useful effect.

The machinery of a chain-towing steamer, the most perfect type of which, as worked on the Elbe, is given in Fig. 3A, consists of a pair of drums worked by gearing from engines of 80-horse power. At each extremity it is furnished with long outriggers, pivoted at one end, the other projecting beyond the the ends of the vessel, formed of double T irons, holding a series of loose pullies and a pair of vertical guides. Between the drums and the outriggers there are 16 or more horizontal pullies placed in a gutter of about 10 inches wide by 8 inches deep, and four or more vertical guides for supporting and guiding the chain.

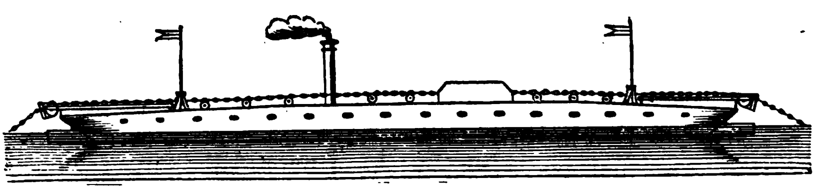


Fig. 3A.

The chain is taken on at the stem, and dragged between and over the pullies and guides to the drums, which are massive castings of chilled cast iron or cast steel. The peripheries of these are divided into grooves to prevent the triple rounds of chain in their passage over the drums from getting entangled together. Thence the chain runs along the gutter, supported by the loose pullies, and over the outrigger, where it is paid back again into the water. The objects of the outriggers are firstly, to allow the chain to come on or to run off the steamers without

cutting into the edges of the deck or fenders, and to clear the rudders; and secondly, in passing round curves, to allow of its being taken up and run out at an angle to the line of the steamer's movement. In front and astern of the drums there are wells for containing the slack chain, should there from a surplus quantity of chain be no strain astern of the drums to haul the chain from off the vessel. This slack remains until the tension behind draws it away again into the river.

Without going further into the matter here, it will be well, nevertheless, to point out the drawbacks to this system of towage. From its form, a chain in movement will develop more friction than any other body of equal weight. The grooves of the drums, around which the chain passes three times, whatever may be the material they are composed of, get unequally worn away after a few days' work, partly on account of the varying strains and unequal hardness of the metal, and partly on account of the relatively different tensions, on the first, second and third turn of the chain round the drums. As soon as the diameters of the different grooves of the drums are rendered unequal by being worn away, a series of false strains are developed on the chain through these unequal diameters, and hence the chain must either slip, give in length, or snap asunder. We may add here, that breakages of the chain always occur on or between the drums, and that last year on the Upper Elbe, in a length of 207 miles there were 322 breakages. It is for this reason that the cable which was originally adopted of $\frac{3}{4}$ in. iron has been gradually increased to one of 1 in.; and in some places to 1 1-16th in. iron, in the hope of remedying these breakages by offering greater resistance to the strains which cause them. It has still to be seen whether this is a step in the right direction, and whether, if the chain be increased to such dimensions as to be practically strong enough to resist any effort that can be brought upon it, the engines, gearing, and drums will not suffer more in consequence. In its entire passage over the steamer, besides the drums, the chain comes into contact and friction

with 28 different points of support, which are constantly requiring repair and renewal. The steering power of a chain steamer is also defective, in as far as beyond the heavy chain hanging down from it at each end, it is held to a rigid base on the chain, comprising the entire distance between the ends of the outriggers, over 140 feet; and, moreover, as the deviation from the straight line of the outriggers themselves is confined to 14° each way, as shown in Fig. 4, the steamer's capability to move out of the channel to avoid collisions, is limited. The continual hammering, grinding, and jolting of the chain in its passage over the steamers, besides causing great outlay for repairs, racks them to pieces in a few years.

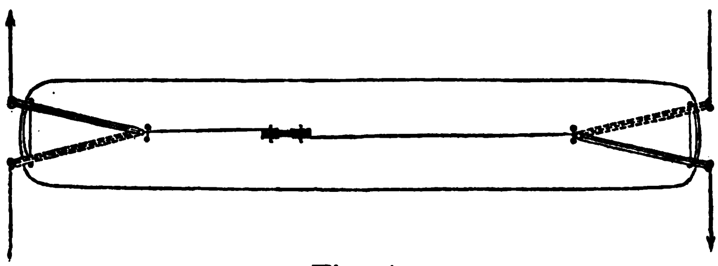


Fig. 4.
Length of steamer confined to chain.

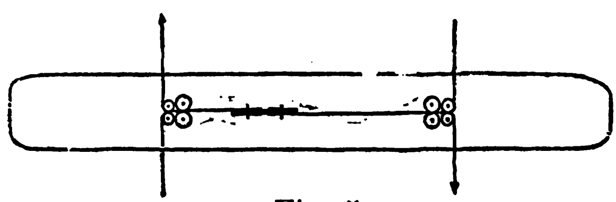


Fig. 5.
Length of cable base on Type B of cable steamer, with self-adjusting taking-in and paying-out gear.

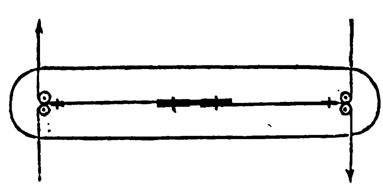


Fig. 6.
Length of cable base on Type C. of cable steamers.

WIRE CABLE TOWING STEAMERS.

By most of the advocates of Wire Cable, the clip pulley was considered to be the grand solution of all the difficulties presented by the use of this regular, smooth and elastic material for towage. With all due respect for an invention which has proved of so much utility and value in other respects, we must nevertheless confess, that for the purposes which we have now under consideration, it is not suited. It is perfectly true that it obtains a perfect grip on the cable, but it is at a great sacrifice. The cable is jammed between the jaws of the pulley; but each jaw leaves its mark every time the cable passes over it. Under heavy strains ever so small a slip of the cable over the edges of the 48 or more jaws on the periphery and the pulley must of necessity cause injury to the cable. After some months' use the whole surface of the cable is found to be covered by a series of small cuts, which of course represent o much wear of it. When the strains are constant, the length of cable to be used and its cost of little account, speaking comparatively, Fowler's pulley is excellent. But when the strains are constantly varying, the wear and tear a question of importance, it is unsuited for the purpose. It has, however, been adopted and employed in several cases, principally because it allowed of the steamer leaving and retaking the Wire Cable easily; but this facility has in every case been acquired at the sacrifice of steering power, stability and cable. A few years back Messrs. Fowler, assisted by Mr. Eyth, designed one or two Wire Cable towing steamers, in one of which of 20 H.P. the pulley was placed vertically projecting from the vessel's side as shown in Figure 7, while in another of 15 H.P. it was laid horizontally under the deck as shown in Figure 8. In the steamers designed by Director Schwarz for the Upper Rhine, the Fowler pulley is also placed projecting beyond the steamer's side, as in Figure 9, while in another case a steamer was designed for the Danube by the Danube Navigation Company in which the arrangement is modified as shown in Figure 10.

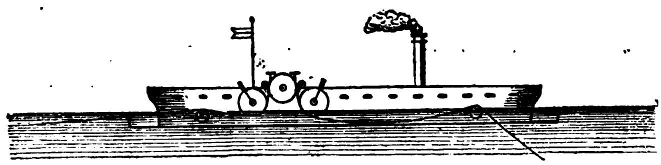


Fig. 7.

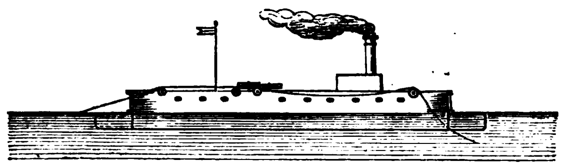


Fig. 8.

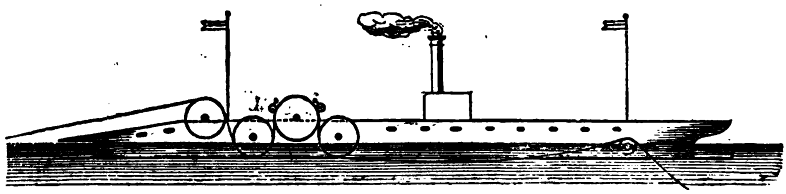


Fig. 9.

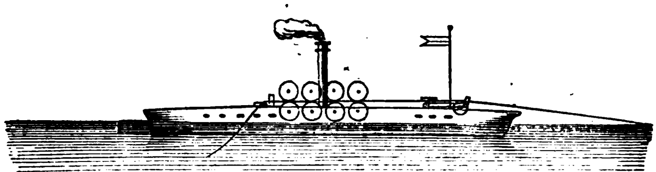


Fig. 10.

In M. De Mesnil's system, as carried out by Mr. Charles Beer, of Jemeppe, the Fowler pulley is also employed, and is placed equally at the vessel's side, driven by 20 horse-power engines. Some of these boats are furnished with auxiliary screws, and all with stem and stern rudders to increase the steering power on account of the light draft. Now in all of them, when the cable is taken over or along the steamer's side, the steering power always is extremely defective, and when the cable is taut in front and astern of the vessel, she is utterly

deprived of all steering power in the opposite direction. In all these vessels, the principle of the side wheel arrangement is the same throughout. In rising from the water the cable passes over a small loose guide at the stem, and hangs along the vessel's side till it reaches the middle, where it is passed under a large guide pulley held in position by blocks working in a slide and backed with a spring; here it is guided on to the Fowler pulley, by means of which the power is applied to the cable, which on leaving the Fowler drum passes under a second guide pulley similar to the one on the other side, whence it likewise runs over a second loose guide placed at the side of the stern of the boat. The most conspicious defects, evident even to the uninitiated, are unequal distribution of weight in the steamer, unequal distribution of strains, application of the engine power at a leverage equal to the distance from the centre of the shaft and clip pulley to the line of travel of the pistons on the one, and to the vessel's centre line on the other hand, and consequent loss of power, less stability, liability to injury from sudden strains, great friction of the cable and bending it suddenly in two different directions causing displacement of the strands, greatly decreased steering power, and impossibility to work curves on the side opposite to that on which the cable is attached to the vessel, or to move out of the channel to avoid collisions or stoppages except on the one side, and liability to injury and possibly the loss of the guide wheels, should kinks or knots occur in the cable. And the one apparently redeeming feature is the possibility of throwing off the cable. It must not, however, be supposed that this is an operation that can be performed at an instant's notice in time to avoid a catastrophe arising from collision or from any possible injury to the cable. On the contrary, the cable has first to be freed from the large centre guide pullies and from the Fowler clip pulley, and then from the end guide wheels. Beyond this it is difficult to find any arguments except in disfavour of the entire design.

Reflection will show that there are several points to be

considered in order to arrive at a satisfactory solution of the difficulties peculiar to the whole system of towage, and therefore our attention from the first has been carefully devoted to designing a type of wire cable towing steamers which should fulfil the following requirements :—

1st. To obtain a perfect hold on the cable without undue friction or injury to it.

2nd. Great steering power.

3rd. Light draught.

4th. Economy in working expenses and maintenance.

To obtain a perfect hold on the cable two ways are open: the one by means of the Fowler clip drum, around which the cable makes half a turn, procuring perfect adhesion; the other by employing two drums with smooth surfaces, and by winding the cable round them such a number of times that the adhesion on the two surfaces should exceed the maximum working strains to be brought to bear upon the cable. And it is the latter means that we have adopted and carried out.

The objection urged against this method, the validity of which, however, cannot be admitted, was that it is practically impossible to drop the cable at any moment during work. The only reply to be offered to this is that a true towing steamer is no more intended to run without cable or chain than is a locomotive without rails. In this respect the two systems are so analogous, and the efforts and forces concerned so similar, that the comparison will hold good if carried still further by adding that it would be as difficult to combine a general harmony of design in a locomotive intended to run on rails and equally well on a common road, as it would be to invent an efficient towing steamer to work equally well with or without cable or chain.

That the manner in which we fulfil the requirements specified in page — may be understood and appreciated, we will here describe generally our types of towing steamers.

In the centre or mid line of the towing steamer, and raised to a sufficient height, we employ two metal drums, the

periphery or outer circumference of which is divided into five grooves. These drums are made conical, so that the length of each groove measured round the circumference of the drum is different, greater or less than the rest, to correspond with the difference of the strains developed by the tension of the cable; or in other words, by the power transmitted from the engines to the drums and from the drums to the wire cable. The grooves are lined with hoop iron of superior quality, bolted down to the metal composing the drums, in order that any wear and tear consequent upon the continual passage of the wire cable may not wear away the surface of the grooves, and hence alter their relative lengths. This arrangement allows of the hoop iron being speedily changed (and these relative lengths exactly maintained) with little loss of time.

These drums, revolving upon strong shafts, are worked by double sets of gearing from the engines, for fast and slow motion; but that their speeds, which vary under different strains, may correspond and be regulated exactly, they are coupled together by means of the three-toothed wheels, one of which is a friction wheel.

This form and arrangement of drums ensures the perfect adhesion of the cable without any friction due to its slipping on them,* it obviates any gripping of the cable to obtain such adhesion, and at the same time it allows of the cable being brought along the mid line of the steamer, or above the keel-line, so that full steering power can be exercised without having first to overcome any tendency sideways as heretofore, owing to the line of effort not being one with the line of resistance. Furthermore, the steamer can be worked forwards and backwards equally well in consequence of this arrangement.

* As a proof of this we have now in work on the river Havel two cable steamers which have already each travelled over 6000 miles on the cable; the wear and tear of the hoop iron with which the grooves are lined, carefully measured with a template has not yet reached $\frac{1}{32}$ of an inch, and very frequently 20 and 25 barges are towed at a time against a heavy wind along a lake, in some parts, over a mile wide and exceeding 60 feet deep.

A loose pulley raised or lowered by a lever is placed between the drums below the lower line of their circumference, for the purpose of insuring the adhesion of the cable to the drums when necessary.

The shafts carrying the drums also support the transmission pullies which by means of two endless Wire Cables held at the vessels extremities by pullies, transmit the necessary movement from the engine to the taking-in and paying-out apparatus, termed a " truck," to be describad hereafter.

In order to regulate the speed of the gearing pullies, they are constructed with a special arrangement of frictional gearing which can be regulated to support any desired working strains.

The taking-in and paying-out apparatus, one of which is placed at each end of the towing steamer is employed for the purpose of guiding the Wire Cable with a certain tension on to the drums and of relaying it from the steamer as it leaves the drums.

This apparatus comprises a strong framing of angle iron, and is furnished below with small wheels by means of which it runs on and is held down to rails of proper form bolted down to the deckbeams. At either end of the rails a small buffer is placed to break the shock of any sudden motion of the truck up or down. The truck is furnished with 4 horizontal press rolls, two above and two below, working in pairs on two upright shafts. The lower pair of press rolls receive and transmit the power from the engines, and the upper pair guide and pay the cable on to and draw it off from the drums and relay it. These press rolls are cast iron wheels carrying at their periphery sixty teeth working on India rubber rings. These teeth are cast in metal and their outer faces bear the impress of the strands of the cable so that the latter in passing between them may receive or transmit power without friction or injury to either. The truck carries in front two large hollow vertical drums for guiding the cable during the passage of curves between the press rolls, and is furnished above and below with several small horizontal pullies for supporting the wire cable horizontally.

The engines being started, the drums and the transmission pullies commence to revolve, and the transmission cables driving the lower press rolls of the forward and after truck, the cable is paid on to and drawn off from the drums at the requisite tension, by the revolution of the upper press rolls. The accelerated speed of these press rolls which is advisable in order to obtain a slight tension of the cable, fore and aft of the drums, is regulated by the frictional gearing of the transmission pullies, which can be arranged to work at any tension by tightening or loosening the friction rings. As the cable passes from between the upper press rolls of the fore truck, it runs straight on to the first groove of the forward drum. The cable revolves round the drums, and then runs to the after truck, where it passes between the upper press rolls, and is paid out over the stern of the steamer. When following a straight line both trucks stand, as nearly as convenient, to the extremities of the steamer, and the cable rises from and is paid out into the water without touching any portion of the vessel's sides or ends. When the steamer rounds a curve, the forward truck by the sideward pressure of the rising cable runs nearer to the drums, and takes the cable over at one angle, equal to that formed by the radius of the curve with the centre line of the drums. And in very sharp curves the after truck also runs nearer to the drums, and pays the cable out equally over the side, without the cable touching the steamer's side until in passing a curve of sixty degrees, the cable comes in contact with the side guide pullies.

From this general description it will be seen that although we employ our force in direct haulage upon the cable, yet that in so doing we have taken every efficient precaution to protect it from friction and rough usage. That the adhesion of the cable to the drums is perfect in our system is proved by the fact that with a tension on the cable in front of the drums of 50 cwts., the tension on the cable aft of them does not generally exceed 12 lbs., and is not as much as the weight of that portion of the cable suspended between the drum and the paying-out

apparatus.* In towing round curves where possibly the cable is laid sparingly, of course the cable may be taut in front and astern of the steamer, and other forces then come into operation; but these do not in any way affect our principle of the drums. By bringing the Wire Cable along the steamer's centre line we obtain greater steering power than by any other existing arrangement embracing the use of a clip-drum or of any other similar apparatus requiring to be placed in any position along the side or jutting out beyond the side of the steamer. In regard to steering power also it is much increased by the comparatively longer rise of the cable on our steamers. The advantages secured by the use of the moveable trucks for taking-in and paying-out the cable in front and astern of the drums are firstly, that they enable a steamer to tow in every different depth of water under different strains (which give different vertical angles to the cable), and secondly, that in going round curves the length of rigid cable on the steamer can be reduced by the trucks running closer up to the drums (Figures 5 and 6), and thereby to increase her steering power when most required, and at the same time to avoid friction of cable and apparatus due to the horizontal angles formed by the cable with the centre line of the steamer. The symmetrical arrangement of drums, engines, gearing and other apparatus obviates the necessity hitherto recognized of employing a certain amount of dead weight in other parts of the towing steamer as a counter balance to the irregular position of the machinery, and thus allows of obtaining a minimum draught.

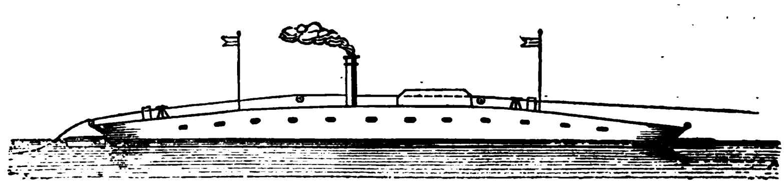


Fig. 11.

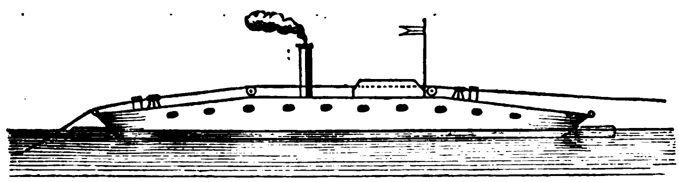


Fig. 12.

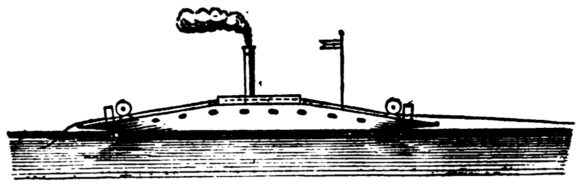


Fig. 13.

By bringing the wire cable along the steamer's centre line forward and backward motion is rendered more easy and regular, and the employment of our apparatus allows of the steamer working as well backwards as forwards, without having to turn her round in changing the direction of her movement.

The outlay for maintenance and repairs is reduced out of all proportions with that required for chain steamers, or for the clip-drum arrangement of cable steamers, as we have throughout reduced all friction and wear and tear to a minimum. The engines and their gearing are completely isolated from the deck and sides of the vessel, and are fastened directly by strong framing on the floor-beams and keelsons, so that the strain acting upon the engines and gearing shall not be transferred to the weak parts of the vessel's hull, while collisions or other injury to the hull as well as the strains acting thereon, shall not affect the engines.

In designing the steamers for the different work they are intended to perform, we have classed them into three types. Type A (figures 11 and 14), is designed for heavy traffic or swift flowing rivers, or against rivers on which there is a strong ebb and flood. This is a steamer which has been specially designed and approved for the river Oder. It is shown in the frontispiece, the sole difference between the two being that in the first case

the press rolls are fixed; and the taking-in and paying-out apparatus are also fixed at either end of the steamer; whereas in figure 11 the press rolls and taking-in and paying-out apparatus are combined in one apparatus, and made moveable. This class of steamer is fitted with engines of 50 horse-power nominal and two boilers. Its principal dimensions are as follows:—

TYPE A.

	Ft.	In.
Length of Hull on deck line	129	10½
,, ,, water line	123	4
Beam	16	5
Depth at centre	8	5½
Draught	1	9
Total height	11	9½
Engine	50	H.P.
Diameter of Cylinder	1	ft.
Stroke	2	,,
Revolutions per minute	45 to 50	
2 Boilers .... each	323	ft.
heating surface working to pressure.	90	lbs.
Revolutions of drums up-stream	$= \frac{44 \times 22}{96} = 10$	
per minute, or down-stream	$= \frac{45 \times 50}{75} \times \frac{75}{75} = 30$	
per minute.		
Low speed 210 ft. per minute	= 2·2 miles	
per hour.		
High speed 617½ ft. per minute	= 7 ,,	
per hour.		
Weight of Hull—Ironwork	62,169 lbs.	
,, ,, Woodwork	23,757 ,,	
,, Fittings	15,400 ,,	
,, Engines	15,776 ,,	
Carried forward....	**117,102 lbs.**	

Brought forward....	117,102 lbs.
Weight of Boilers	22,770 ,,
,, Gearing	24,813 ,,
,, Cable apparatus	16,794 ,,
,, Fuel and water....	17,050 ,,
Total displacement weight	200,875 lbs.
or 89 tons 13 cwts. 2 qrs.	

The weekly average working expenses of this class of steamers, inclusive of repairs, amounts to £20 8s.

Type B (Fig. 12) is designed for heavy river, lake or canal traffic, or where the channel is confined and tortuous. The power of the engines is similar to type A, the principal difference in the design consists in its being shorter and wider.

TYPE B.

	Ft.	In.
Length of Hull on deck line	108	3
,, ,, water line	101	8
Beam	19	8
Draught	1	9
Total height	11	9½
Engines	50 H.P.	
Diameter of cylinder	1ft.	
Stroke	2ft.	
Revolutions per minute	45 to 50	
2 Boilers .... each	323ft.	
Heating surface working to .... pressure.	90 lbs.	
Revolutions of drums up-stream	10	
,, ,, down-stream	30	
Low speed 210 ft. per minute .... =	2·2 miles per hour.	
High speed 617½ per minute .... =	7 miles	

Weight of Hull—Ironwork	62,169	lbs.
„ „ Woodwork	23,757	„
„ „ Fittings	15,400	„
„ „ Engines	15,776	„
„ „ Boilers	22,770	„
„ „ Gearing	24,809	„
„ „ Cable apparatus	16,794	„
„ „ Fuel and water ...	17,050	„
	198,525	lbs.

Total displacement weight = 88 tons 12 cwts. 2 qrs.

The weekly average working expenses of this class of steamers inclusive of repairs amount to £20 8s.

Type C (Figure 13) has been designed especially to suit canal traffic or that of a small and swiftly flowing river. It is furnished with engines of 25 horse power, and the engines, gearing and apparatus are designed as compactly as possible. As the length is comparatively short, 62 ft. on the water line, the taking-in and paying-out gear is not made moveable, but is fixed together with guiding drums, at each end of the vessel, forming, however, a rigid cable base on the steamer of only 59 ft. This steamer requires a crew of three men to work her. The principal dimensions are as follows:—

TYPE C.

	Ft.	In.
Length of Hull on deck line	78	8
„ „ water „	62	4
Beam	14	9
Draught	2	$0\frac{3}{4}$
Total height	11	$5\frac{1}{2}$
Engine	25 H.P.	
Diameter of cylinder	10ft.	
Stroke	2ft. 1in.	
Revolutions per minute	50	

1 Boiler	430ft.	
Heating surface, working up to .... pressure per square inch	90 lbs.	
Number of revolutions of drums up and downstream .... $50 \times \frac{8}{20} =$	20	
Speed up-stream 395 ft. per minute.		
Average of speed 4·6 miles per hour.		
Weight of Hull—Ironwork	33,389	lbs.
,, ,, Woodwork	10,758	,,
,, ,, Fittings	10,560	,,
,, ,, Engines	11,000	,,
,, ,, Boiler, chimney and connection	15,180	,,
,, ,, Gearing	16,830	,,
,, ,, Boiler water	3,960	,,
,, ,, Fuel	4,400	,,
,, ,, Cable, crew, etc.	880	,,
	106,957	lbs.

or total displacement weight 47 tons 14 cwts. 3 qrs.

The weekly average working expenses of this class of steamers inclusive of repairs amounts to £15.

In all these three types of steamers brakes for stopping can be worked from the deck. They are designed to be fitted with steam-steering apparatus and with ordinary helms.

Possibly there may be circumstances of a special nature in some cases, where cable towage could advantageously be adopted, which would require a design of steamers differing in some of the details from either of the three types we have mentioned here; but considered as a general design they embrace all that is requisite.

A further advantage of an efficient system of wire cable towage is, that when once a proper cable has been laid down, towing steamers of any different sizes and power within the fair limits of the cable's strength can be conveniently worked upon it,

should the traffic be intermittent; whereas on chain, as in the case of some parts of the Elbe, where one of 1 1-16th is in use in some places, it would be impossible to put a 20 horse-power steamer to work.

We append hereto a table of the maximum working capabilities of wire cable towing steamers deduced from trials we have carefully worked out.

In conclusion we may add that there are many rivers and canals in the United Kingdom, as well as in other countries, where this system of cheap and regular goods traffic, once known, might be successfully carried out, and that in many of the British colonies instead of building costly and useless railways, attention might be far more advantageously devoted, and capital usefully and carefully employed to improve and render available for the transport of produce the thousands of miles of magnificent waterways they possess.

F. J. MEYER.
W. WERNIGH.

BERLIN, S.W. 1876,

9, Hedemann Str.

Patentees' Representative in the United Kingdom,

H. R. MEYER,

B 12, Exchange Buildings, Liverpool.

TABLE OF WORKING CAPABILITIES OF WIRE CABLE TOWING STEAMERS
in still water, at different speeds, with Barges of different draughts, empty and laden.

Total resistance to tractions of steamer and train in lbs. = P
Speed in feet per second .... = V
Immersed section .... = F
Resistance of vessel in lbs. .... = W

$$H.P. = \frac{P \times V}{550}$$

DIMENSIONS.

				Load or Cargo in Cwts.
Empty Barge ...	L = 131′10″	B = 14′11″	D = 1′6″	—
„ Lighter ..	L = 131′10″	B = 14′11″	D = 8″	—
Laden Barge ...	L = 131′10″	B = 14′11″	D = 3′3″	1571
„ Lighter ..	L = 131′10″	B = 14′11″	D = 3′3″	2455

	MAXIMUM EFFECT IN NUMBER OF BARGES TOWED.		
CONDITIONS.	50 H.P. Engines, V = 3′3″ per second or 2·2 miles per hour, with P = 13 cwts.	25 H.P. Engines, V = 6′6″ per second or 4·4 miles per hour, with P = 18 cwts.	25 H.P. Engines, V = 3′3″ per second or 2·2 miles per hour, with P = 36 cwts.
Empty Barge... F = 21·6 square feet, W = 66 lbs.	125	—	62
Empty Barge... F = 21·6 square feet, W = 286 lbs.	—	7	—
Empty Lighter, F = 9·6 square feet, W = 29 lbs.	287	—	144
Empty Lighter, F = 9·6 square feet, W = 121 lbs.	—	17	—
Laden Barge ... F = 48·4 square feet, W = 150 lbs.	55	—	27
Laden Lighter.. F = 48·4 square feet, W = 605 lbs.	—	3	—

This Table is based upon the results of our dynametrical trials, regard being had to the co-efficient (·3) of the ship's resistance upon which these trials were carried out.

APPENDIX.

The present encumbered state of many English lines of railway and the continually increasing—and we may add, costly struggle they have to maintain in dealing with vast quantities of mineral and other cheap traffic, notwithstanding the splendid network of canals spread over the whole country, and especially the industrial parts of it clearly show that there is room for improvement in the utilization of these comparatively neglected, but invaluable highways.

We have spoken with many people variously interested on this subject, and its truth and importance is generally admitted ; but, irrespective of one or two technical difficulties, such as locks and bends, the gravity of which is however much exaggerated, there appears to be a general conviction that such a thing as a fair and reasonable co-operation between railways and canals would meet with determined opposition on the part of the former.

We are, however, in a position to deny the justice of this opinion so far as some of the principal lines are concerned, although we admit that formerly this might have been the case. At present, however, when the largest portion of the commerce and trade of the whole world is centred in and about England, many lines would be only too glad to transfer much of their cheap and unprofitable traffic to the canals, where it could be made to pay the canal owners well, and be carried at far lower rates than are now charged by the railways.

By this means many lines which are now spending millions annually in so increasing their permanent way and plant so as to enable them to deal with the immense quantities of cheap traffic which is thrown upon them, would be relieved from this constant and apparently endless outlay or increase of capital, while another immediate result would be, increased security and capacity for passenger and ordinary goods traffic, and at rates remunerative to the railways and satisfactory to the public.

We have shown in the accompanying pamphlet that towage assures a punctual and speedy forwarding of traffic, and that it vastly increases the carrying capacity of any waterway to which it is applied. It is analogous to the working of railways by steam, and we may, not inappropriately remark, that if railways had been worked by means of horses hauling single trucks in something like the way canals are now managed, they never could have accomplished the hundreth part of what they have done.

In the case of existing English canals the principal difficulty to which reference has been made is the locks, for with an efficient system of cable towage the curves or bends on canals are, practically speaking, no difficulty whatever. It is only in the case of swiftly-flowing rivers that special arrangements are requisite for working round very sharp curves.

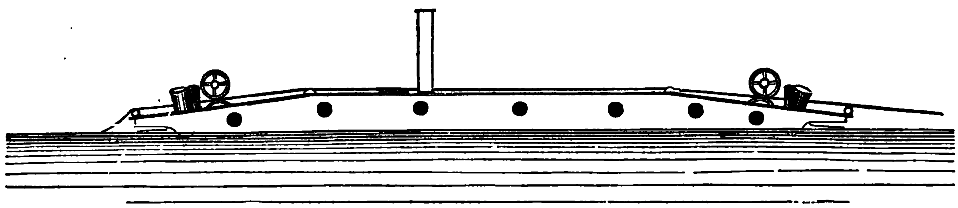
The locks do constitute a difficulty, inasmuch as they occasion delay in the passage of trains of barges. At present the barges towed by horses one by one along the canal, arrive in this manner at each succeeding lock, and are lifted or let down, as the case may be, without regard to time. A train of barges arriving at a lock would, under the existing state of things, have to be locked up or down, also one by one, and consequently some part of the time saved by the towing would be wasted at each lock. The great increase of paying traffic which would undoubtedly accrue by the adoption of tcwage on the canals, would however justify some expense being incurred in modifying many of the present single locks, or where several are close

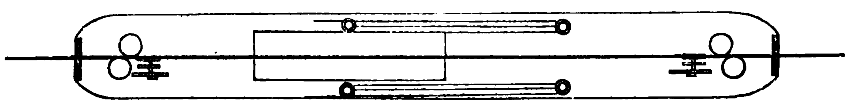
together, in running them into one lengthened lock, so as to admit of a whole train of barges being locked at once; where tiers of locks occur, these would be most satisfactorily dealt with by doing away with them altogether, and adopting proper hydraulic barge lifts, similar to those working at Anderton. With a properly arranged traffic, the waste of water, in the first case, would not be more than working each lock and barge separately; whereas, in the second case, if the supply of water is limited, there need be no waste at all. There are many long stretches of canals, however, quite free from any locks, and these therefore require no further outlay than is necessary for the direct application of the system to make them most invaluable highways of traffic and increase their usefulness tenfold, whereas they are now neglected and a source of sorrow to their owners. Cable towage does not in any way necessitate altering the present barges, dimensions of the canals, overbridges, wharves, or towing paths. One direct advantage however would be, that in course of time, the maintenance of towing paths would be totally avoided, as well as injury to the banks from wash of the water. It must be recollected that this system entirely obviates the washing of the banks, as the motive power is applied not to the water, but to the cable lying on the bottom of the canal, and that the speed at which the towing of a whole train is effected, say four miles an hour, does not form a larger wash-wave than that raised by a single barge towed by horses.

The application of this system furthermore, would not in any way impede or obstruct towing by horses, although we are convinced that in a comparatively short time there would not be a single barge owner who would not prefer to have his boats forwarded by steam towage; for irrespective of cost, with him as with every one else, time and regularity must be considerations of ever-increasing importance.

In order to suit the exceptionally small dimensions and other technical peculiarities of many of the old canals and locks

in England, we have designed and patented a type of steamer specially adapted for working them.





The dimensions of this class of towing steamers is as follows :—

Length over all	....	 60	feet.
,, at water line	....	 52	,, 6 inches.
Beam	....	 7	,,
Draught in work ...	....	 2	,, 9 ,,
Total clear height from bottom		 8	,, 6 ,,
Height above water	....	 6	,,
Nominal horse power of engines		 15	,,
Length of boiler	....	 9	,,
Diameter of boiler	....	 4	,,
Grate surface	..	 10	square feet.
Heating surface	....	 267	,,
Diameter of drums	....	 5	feet.
Speed per hour	....	 4	miles.

Steel wire cable, diameter ⅝ inch, weighing 3½ lbs. per fathom, ultimate strength 27,000 lbs.

The total weight of steamer with gearing, fittings, fuel, &c., in complete working order, is 23 tons.

This class of steamer is designed to tow a train of about

800 tons floating weight, or say 600 tons nett cargo weight, at about four miles per hour along a canal.

The entire crew of a steamer consists of two men, and a boy to look after the tow ropes. The Cable is provided with the necessary couplings at the junction of branch canals with the main line, which correspond to the points on a railway, so that the traffic may be worked from these direct on to the main line.

The annual expenses, including depreciation of first cost of plant, and repairs of an entire line of 100 miles, to work a traffic of 500 tons a day, presuming there are no special difficulties in the case, are covered by a charge of one-eighteenth of a penny per ton per mile; while for a heavy traffic of some thousands of tons daily, the working expenses will be comparatively less.

Of course we do not attempt to make any comparison in point of speed with railways, but we are convinced that there is no railway in existence of which the total cost of traction, including maintenance and repairs of permanent way, can be covered by one-eighteenth of a penny per ton per mile. In point of cost moreover, irrespective of every other consideration, we even doubt whether the present antiquated mode of haulage by horses, mules or donkeys, can compete with these rates.

By the introduction of this system it is not sought to compete with railways, but to aid them in that part of their traffic which is worked, directly or indirectly, at a loss. No doubt it will at first find determined opponents, some from reasons of fancied danger to their interests, others from not understanding the subject. But as railways have lived down the enormous opposition raised against them when first projected as being impracticable schemes, so it is hoped will this practical solution of the question of cheap and regular inland water carriage, and by revitalizing our invaluable but neglected waterways, be a further means of aiding industrial England in her competition with the world.

Fig. 14.

VI

INDEX.

INDEX.

INDEX.